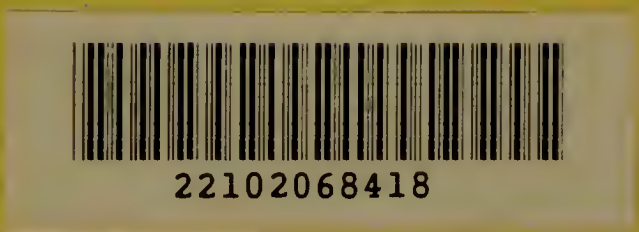
THE CLINICAL EXAMINATION OF THE URINE.



Dr. Andrew Clark.

With the Author's kind regards.

THE CLINICAL EXAMINATION

OF

THE URINE

IN RELATION TO DISEASE.

BY

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THE CLINICAL EXAMINATION OF THE URINE IN RELATION TO DISEASE.

The question of the changes which the urine undergoes in the many and varied diseases which afflict the human body, is one of great importance in its practical application to the healing art. It must, however, be confessed that, notwithstanding the progress which medicine has continued to make from the time of Hippocrates, Galen, and the Arabian physicians, even to the present period, there is, perhaps, no subject in medicine of equal importance, which has, in a practical point of view, made fewer strides towards that perfect knowledge at which it is one of the great objects of physicians to aim, than that of the clinical investigation of the changes which are produced in the urine by disease. It is true, that with the advancement of animal chemistry, especially within the last thirty years, the chemico-physiology of the urine has wonderfully increased our knowledge of the functions which are by nature assigned to the different portions of the kidney—of the nature of the urinary secretion in its relation to the metamorphosis of the tissues of the body—of the many complex constituents which are embraced by the solids of that secretion—and of the influence which food, exercise, and rest, exert upon the absolute and relative proportions of those solids, as well as upon the quantity of fluid by which they are held in solution.

In all these particulars we have reason to be satisfied with the progress we have made and the results at which we have arrived. To the attainment of this great increase of knowledge, the labours of both continental and British investigators have probably equally contributed. Whilst I write, a host of honoured names presents itself to my memory. Some of the bearers of these names have already passed away, and have left in their works imperishable records of their fame. Others yet remain, to add, let us hope, still

further to their contributions to our knowledge, and thus, whilst shedding additional lustre upon their reputation, to advance the great object of true medical art—the cure of disease and the physical happiness of mankind.

Of the names of those who have by their labours contributed to this knowledge and to this end, I almost fear to make mention, lest I should inadvertently omit the name of some one who has, at my hands, equal claims to recognition with those whom I should feel it no less a pleasure than a duty to particularise. Still, where no unworthy motive has influence, and where no slight is intended, no real imputation can lie. In this feeling and with this conviction I venture, then, to pay the homage which medicine owes to its benefactors of whatever country or clime. There is in the medical profession a special bond, as there is in the human race a common brotherhood, which binds us to one another in thought—in feeling—in the noble aspirations of the heart to minister to the good of mankind—and in the realization of those aspirations by individual successes wheresoever and by whomsoever achieved. I speak of the labours of continental investigators in urinary chemico-physiology, and medicine, in its British representatives, at once acknowledges its obligations and its gratitude to Berzelius, Boussinganlt, Scherer, Simon, Heller, Pettenkofer, Becqnerel, Mulder, Wohler, Liebig, Lehmann, Heintz, Schweig, Schmidt, Laskowski, Lecanu, Funke, Neubauer, Vogel, Eckhard, Thudichum,* and others.

I turn to the pages which record the results of the labours of our own countrymen in this department of medicine, and there I find the names of Prout, Henry, Wilson Philip, Routh, Christison, Ure, Bird, Rees, Garrod, Bence Jones, Ronalds, Percy, Beale, Hassall, Pavy, W. Roberts of Manchester, and many others, who command the same acknowledgment of gratitude and, although it may not be an equal claim, yet still a claim, to distinction on the roll of fame. Much, it must be confessed, has been done by these enquirers; yet much remains to be done even in the particular direction in which they themselves have so successfully laboured, before our knowledge of the urine, in relation both to health and to disease, can be considered at all complete. The investigation of the urine in disease has not kept pace with the chemico-physiology of that secretion, although, by the joint aids of chemistry and the micro-

* Dr. Thudichum, although practising in London, I have, in consequence of his nationality, classed with continental investigators.

scope, our knowledge of urinary pathology has, of late years, considerably advanced. But our greatest lack of information is in the observance and appreciation of those changes which disease produces in the quantity, density, and colour of the urine, and of the nature and constitution of the deposits which occur in it, as well as of the adventitious products which are held in solution or suspension by it in some or all of the phases of disease. In this particular direction there is great need for future enquiry, which, if properly carried out, would lead to very important practical results. In entering upon this particular subject, which may not inaptly be termed the semeiology of the urine, a knowledge of healthy urine, as to its daily quantity, density, colour, chemical constitution, and as to the variations which these may undergo within the range of health, is absolutely necessary, in order that those deflections from health which occur more or less in disease, may be recognised, appreciated, and made the ground for legitimate deduction and treatment.

The kidneys are one of the great highways along which the exhausted tissues are conveyed from the body. They are no less the channel by which substances incapable of entering into the formation of the organism, are removed either unaltered in the condition in which they were presented to the system, or after having undergone a certain change or metamorphosis in their molecular arrangement and chemical constitution. The function of the kidneys is therefore highly conservative of health and of life. Let this function be so deranged that the elimination of urea bears no proportionate ratio to the destruction of tissue which is taking place in the body, and serious results at once occur. These may issue in violent sickness and vomiting, in severe frontal headache, in convulsions, in coma, and in death, according to the interruption which exists to the eliminating power of the kidneys and to the consequent retention in the blood of the product of the conversion of even healthy tissue into urea, which thus becomes a deadly poison to the body, of which its previously arranged elements, in the form of muscle, formed a component part. Every practical physician is well acquainted with the rapidity with which these results take place in acute nephritis, and in the latter stages of granular degeneration of the kidneys. Here, in the one instance, the secretory portion of the kidney is suddenly invaded by inflammatory exudation; in the other instance, exudation more slowly, yet progressively, occurs; in both, the proper

function of the organ is at last almost, and sometimes entirely, arrested, and death from the retention in the blood of the organic constituents of the urine occurs. If, on the one hand, we look at the chemical constitution of the urine—and if, on the other hand, we regard the chemistry of the tissues of the body—we can readily understand that, in the breaking up and dissolution of the latter in their withdrawal from the body, their ultimate elements are so re-arranged and re-combined as to appear in the derivative compounds and salts which are found in the urine.

The conclusion, then, to which this doctrine leads, regards the urine as the representative of all the dead and dissolved tissues of the body. As the blood is the great vital stream which, in its onward course through all the ultimate ramifications of the body, supplies the pabulum from which every tissue is nourished, so the urine is the great menstruum by which those tissues are, when the vital principle has once quitted their living atoms, conveyed from the body. The one fluid, then, predicates a formative object—the other, a conservative end. Both are necessarily complex in their chemical constitution; both have certain constituents in common; and, where they differ, they differ in those principles which, in the one fluid, have a prospective tendency to organisation; in the other, to the retrospect of transformation, death, and decay.

According to the present state of our knowledge the following represents the constitution of the urine in health:—

TABLE OF THE NORMAL CONSTITUENTS OF THE URINE.

Organic Constituents—
- Urea
- Creatinine
- Xanthine

Inorganic Salts—
- Soda
- Potash
- Ammonia
- Magnesia
- Lime
- Iron

Organic Acids—
- Uric acid
- Hippuric acid
- Phenylic acid
- Taurylic acid
- Damaluric acid
- Damolic acid

Inorganic Acids—
- Sulphuric acid
- Hydrochloric acid
- Phosphoric acid
- Silicic acid

Urinary Pigments—
- Urohæmatine
- Uroxanthine
- Uroërythrine

In the rapid strides which animal chemistry is making, it would be a manifestation of a want of faith in the progress of chemical science, to expect that the analysis of the urine, as now given, will continue to represent our full knowledge of its constitution. There are even now certain constituents whose chemical composition is as yet unknown, and which are, for the want of a more definite knowledge, known only by the vague terms of "undefined principles" and "extractives." I look forward with perfect confidence to the time when these "undefined principles" will, in the progress of chemical science, receive a perfect solution and be reduced to formulæ as accurate as that which represents the chemical constitution of urea. I have equal faith in my impression, that the future of animal chemistry will bring to light other and, as yet, undiscovered principles of the urine, and that the list of urinary constituents will be swelled by additions to our knowledge, of secondary importance only to the great principle of urea. My present object, however, is not with these "undefined," and with these probably undiscovered, principles, but with those which have already been discovered, and whose chemical constitution is well understood. With such my object is, to ascertain to what extent they are increased, decreased, or in any way modified by disease, and to apply the knowledge thus obtained to the mitigation of human suffering and to the removal of its cause. Much information may be gathered by watching, at the bedside of our patients, the fluctuations which these urinary constituents undergo from day to day, the particular periods of the disease at which they occur, and by associating them with the change in degree of symptoms with which they are accompanied, the nature of the disease which exists, and the particular organ which is affected. In this sense the aim and scope of this paper are practical.

QUANTITY OF URINE IN DISEASE.

The quantity of urine in disease must be determined by reference to the quantity which is discharged by the healthy body in a given time. Now, the quantity of urine secreted by a healthy adult has a certain range, and is influenced by certain conditions. Under the ordinary conditions of life the quantity may, for the winter, be noted as forty ounces in the twenty-four hours; and as thirty ounces for the same period during the summer. The cause of the

difference between the two seasons is due to the increased action of the skin during the summer, by which an excess of fluid is carried off, with the effect of producing a proportionate reduction in the quantity of fluid secreted by the kidneys, but by no means in equal ratio to the excess of fluid lost in perspiration. Season nevertheless does influence the secretory action of the kidneys. The particular nature of the food, the quantity and particular kind of drink, exercise, and rest, have likewise their influence. The fluctuations thus produced in the quantity of urine have a healthy range; or, in other words, the quantity of urine may, by these circumstances, be increased or diminished for a given time without being accompanied or followed by the least injury to the system, or by the slightest deflection from health.

Amongst other causes which influence the secretory action of the kidneys, are mental emotions and anxiety of mind.

What physician has not witnessed the effect of sudden grief or joy in producing an excessive secretion of pale, limpid urine, especially in the female constitution? What medical man has failed to observe, if not in his own person, at least in the persons of others, the increased action of the kidneys caused by the anxiety of mind attendant on an impending examination which is to determine the admission or non-admission of the candidate to medical practice?

If the waiting-room, or, what is more commonly called by medical students, the "funking-room," of the College of Surgeons could relate its experience on this particular point, it would give innumerable instances in which candidates, during the short time they were necessarily detained before being ushered into the examination-room, were repeatedly—nay, almost constantly—discharging the contents of their bladder. Now, the condition of system which gives rise to this increased secretion of urine is, in my opinion, neither one of perfect health nor yet of absolute disease. I would, if requested to define its position in medicine, place it on the boundary line between health and disease—a point from which a continuance of the condition would assuredly result in absolute disease; whilst the withdrawal of the cause and the consequent subsidence of the excitement would as assuredly be followed by a return to the previous state of health. This view seems to derive a certain confirmation from the fact, that headache, a sense of exhaustion, and, in many instances, loss of appetite, follow this condition in both the successful and unsuccessful candidates.

If we now advance a step further, and thereby tread within the verge of disease itself, we arrive at the consideration of the influence which hysteria exerts upon the quantity of the urinary secretion. Immediately after the invasion of the attack, in which the more evident symptoms of the affection manifest themselves, the discharge of urine is frequent, and amounts, in the short space of one or two hours, to three or four quarts, or even more. It is always, under such circumstances, extremely pale, scarcely deeper in colour than water, of a very low specific gravity, seldom exceeding 1·007, and faintly acid to test-paper. But this excessive secretion of urine is not constant. It is soon followed by a manifest reduction of the quantity of urine below that of health. The urine now secreted forms a decided contrast, not only in quantity, but also in colour and density, with the urine previously discharged. Not more than four, six, or eight ounces are voided in twenty-four hours. The colour is generally of a deep yellow or reddish-brown, and the specific gravity often reaches 1·028-30. On cooling a heavy sediment of urates intermixed with purpurates in largely increased quantity is thrown down. These appearances are followed by a return to the natural condition of health, although that condition may not be reached for some days after the cessation of the more urgent symptoms which marked the attack. It may here, in the interest of diagnosis, be asked, whether the excessive secretion of urine and the particular character of the fluid as just described, are diagnostic of hysteria? The proper answer to such a question is—that they of themselves are not, that they are a great assistance in the diagnosis of hysteria, and that, where the more prominent symptoms of hysteria are present, they render the diagnosis certain. The practical inference which flows from this conclusion, in reference to diagnosis, is—that the physician should never declare the presence of hysteria from the mere inspection of a large quantity of limpid urine suddenly discharged by his patient.

Closely allied to hysteria, in the effect produced upon the quantity of the urinary secretion, are neuralgia of the cranial nerves and rheumatism of the scalp. In severe tooth-ache, in tic-douloureux, and in severe neuralgia of the supra-orbital nerve, the quantity of urine discharged, after the invasion of the disease, is frequently, but by no means always, in excess of the natural amount. In rheumatism of the scalp, which is of frequent occurrence, but which is not always recognised, the effect upon the quantity of urine is

often rapid and considerable. The disease is generally ushered in by slight indications of cold, followed by a degree of soreness or pain across the brow and at the back of the head, with, not unfrequently, a sense of stiffness of the muscles at the back of the neck. The pain and soreness increase from hour to hour, almost from minute to minute—any motion of the scalp aggravates the pain—the mere effort of evacuating the bladder, but especially the effort of defœcation, produces throbbing of the vessels of the scalp—nausea occurs—vomiting soon supervenes—the pain grows rapidly worse—and the patient becomes almost distracted. During the establishment of these symptoms frequent micturition occurs, and a large quantity of urine is discharged in a very short time. This, like that of hysteria, may amount, in three or four hours, to a gallon or more; it is of the same pale colour, and of similar specific gravity. On the day following the attack all the urgent symptoms have subsided, and the urine has fallen to its natural quantity, or even below it. It is no longer pale and limpid, but of a deep yellow or reddish-brown colour, of the specific gravity of 1·026-30, and deposits, on cooling, a copious sediment of urates so intermixed with the purpurates as to give to the deposit a red-brown or pinkish-red colour, and to leave on the bottom of the containing vessel a coating of a bright pink character in appearance.

In the cold, shivering stage of the commencement of acute disease, as in the different fevers and local inflammations, the quantity of urine is not unfrequently increased for a few hours, or until the stage of reaction occurs. When such is the case, the cause is due to a temporary loss in the balance of the circulation between the surface of the body and the internal organs—the vessels of the skin containing, at this particular juncture, less than their natural quantity of blood, whilst those of one or more of the internal organs contain more than their natural quantity. When this overplus of blood falls upon the vessels of the kidneys, which is often the case, it at once excites the conservative power of those organs, and an increased quantity of urine is the result. As soon, however, as the hot stage of fever, or that sympathetic fever which is the accompaniment of local inflammation, has been established, the quantity of urine undergoes a manifest diminution. This diminution continues until the acme of disease has been reached, when, if the attack is to end favourably, there is a return firstly, to the natural quantity; and secondly, an increased quantity of urine is secreted. These fluctuations bear a more or less proportionate ratio to the

severity of the attack. By applying our knowledge of the duration of disease to this fact, we are enabled to say when, in cases about to recover, a favourable change ought to be expected in the quantity of the urine. If this change does not occur at the expected period, the prognosis is less favourable than before; but it must not necessarily be inferred that the patient will not recover. It nevertheless shows a persistence of the disease in all its severity, and with it more danger to life from the continual addition to the local effects and to the depressing influence produced upon the vital powers. It further shows that convalescence will, if the patient ultimately recover, be deferred beyond the usual period, and that it will advance towards perfect health with a slower and less decisive step. It must not, however, be forgotten that our knowledge of the duration of disease is not yet so complete as to enable us to determine, with perfect certainty, the exact time which the different diseases occupy in reaching their utmost severity or climax. Until we have attained this perfection of knowledge, our predictions as to the day on which an increased quantity of urine may be expected, and our prognosis as determined by the quantity of urine which actually occurs on that particular day, are liable to a certain amount of error. It is true that, in the different forms of fevers, whether eruptive or otherwise, we know the exact period of time which they occupy in their invasion, in their increase, in their acme, and in their decline; but our knowledge is not so exact and precise as to the duration of local inflammations. Much here depends on age, constitution, temperament, habit, the particular organ affected, the type of disease, and the treatment which has been adopted. This, however, is certain—that so long as the quantity of urine remains at the lowest point which it has marked since the invasion of the disease, that disease exists in all its severity; and that as soon as the quantity of urine does exceed the lowest point at which it has previously stood, the tendency to recovery is thereby noted. How much valuable information may be obtained—how greatly may our prognosis be strengthened—how many sorrows may be soothed, by simply measuring, from day to day, the quantity of urine discharged during the progress of acute disease!

If we turn to the effect of chronic disease on the quantity of urine, we find it to be by no means so certain as that of acute disease. Sometimes the urine is increased in quantity; at other times it is diminished, in the same disease. In the different diseases which involve the digestive organs, the daily discharge of

urine is not only unequal, but it undergoes various fluctuations in the same disease. Diabetes mellitus is usually productive of a large increase in the quantity of urine, which amounts at times to three or four gallons, or even more, in twenty-four hours; but diabetes nevertheless frequently exists with no increase, under proper treatment, in the natural quantity of the urine. Organic diseases of the stomach tend to a diminution in the quantity of urine—a fact which may be explained by the general intolerance of food and of drink which is manifested by the stomach under such circumstances.

I have not unfrequently observed that, in sudden congestion of the liver, in the early stage of simple enlargement, and in commencing cirrhosis, of that organ, the secretory action of the kidneys was increased to a certain extent. It is, however, no less true that, when organic diseases of the liver have acquired a certain status, the urine often undergoes a manifest diminution in quantity, which becomes less and less as the original disease becomes worse and worse, until, in many instances, a few ounces only are discharged in the twenty-four hours. The same may be said of the influence which diseases of the heart exert upon the quantity of the urinary secretion. In the outset of simple hypertrophy, as well as in that of diseases of an obstructive character of this organ, a certain turgidity of the blood-vessels of the kidneys is produced, which results, for the time being, in an increased quantity of the natural secretion. As these diseases increase in severity the turgidity of the renal vessels becomes more and more marked; this ceases to excite the secretory action of the kidneys, and a consequent diminution in the quantity of urine takes place; or a low exudation—the result of this congestion—is poured out, the tissue of the kidney becomes gradually invaded by it, disease of that organ itself is thus superadded to the original mischief, and an increased diminution in the quantity of urine occurs. In all diseases of the kidney of an exudative character, the tendency is, to a diminution in the natural quantity of the urine; because such diseases invade by deposit the ultimate structures of the organ, injure them and disorganize them, and thus render them unable, in proportion to the extent of mischief they have sustained, to discharge their proper functions. The influence of tumours on the urinary secretion is, where they offer no obstruction to the circulation, of a negative character; nevertheless there are not wanting instances in my own practice, in which a sudden and copious discharge of urine was

followed by the disappearance, at least for a time, of an ovarian tumour. It may here be very properly asked, whether or not diseases of the skin increase or diminish the natural action of the kidneys. A priori reasoning, based upon our knowledge of the quantity of fluid which is daily cast off by the skin in the form of sensible and insensible perspiration, would lead us to the inference, that diseases of the skin would, by arresting this natural escape of fluid from the system, and by thus throwing it upon other secretory organs, increase, during their continuance, the daily discharge of urine. Experience, however, does not confirm this natural inference ; but here again experience has not yet recorded the results of a long and carefully observed series of investigations, without which it were impossible to give either a direct negative or an affirmative to this question.

DENSITY OF URINE IN DISEASE.

The density of the urine in health has, like the quantity, a considerable range, in which it is greatly influenced by the nature and quantity of solid food and of drink which are taken, by age, and by the amount of bodily exercise which is undergone. This range may be said to extend from 1·007 to 1·030. Within these two extremes the more common range of specific gravity is from 1·016 to 1·024—the former density being favoured by a diet embracing a preponderance of vegetable food, simple drink, and by little bodily exertion—the latter, by a greater proportion of animal food in the diet, by moderate quantities of fermented drinks, and by an ordinary amount of bodily labour. The extreme range of 1·030 is never, at least so far as my own experience goes, reached, except under the use of a highly animalized diet, and even then it is of seldom occurrence ; nor have I ever observed the opposite extreme of 1·007, except under some exceptional conditions of body, or of food, or of drink. It may be very positively asserted, that these two limits of the density of healthy urine are much more frequently associated with disease than with the natural conditions of the body ; but inasmuch as they are at times found to exist with the latter state of health, they are here simply noted as its extremes of urinary fluctuation ; whilst their practical application has far greater reference to disease.

Now, we find that, as a rule, those diseases which increase the quantity of urine, reduce its specific gravity ; or, in other words,

they reduce the relative proportion of the natural solids to the fluid portion of the urine, and thus lower its density. This latter mode of stating the proposition is probably the more correct one; because diabetes mellitus increases the quantity of urine, and with it the density of that secretion, much more than any other disease; but the tendency of diabetes is, nevertheless, to reduce the relative ratio of the natural solids to the fluid part of the urine.

Amongst diseases, the tendency of which is to reduce the specific gravity of the urine, are the different nervous affections, as neuralgia, hysteria, rheumatism of the scalp, granular degeneration of the kidneys, the phosphatic diathesis, the cold stage of commencing fevers, and, in many instances, that period or stage of collapse which ushers in a local inflammation. The degrees of limit within which these diseases influence the density of the urine are 1·002 to 1·016-20, the simple neuralgiæ and other nervous affections influencing the urine in the direction of the lower degree of density; whilst the granular degeneration of the kidney, the phosphatic diathesis, and with this latter the oxalic acid diathesis occasionally combined, and the cold stage of commencing fevers and inflammations, tend to push the urine in the direction of the higher degree of density. In the latter division of these diseases, granular degenerations of the kidney render the density of the urine intermediate between that produced by the purely nervous affections on the one hand, and that which, on the other hand, is the common density associated with the phosphatic diathesis and with the very earliest stage of disease of a purely inflammatory type. Hence, the density of the urine in albuminuria is generally from 1·007 to 1·012-14. Although the commencement of many diseases is associated with a diminished density of the urine, yet the tendency of the great majority of those diseases is, as they approach their termination, to increase the density of that fluid. This is true of the pure neuralgiæ, hysteria, rheumatism, fevers, and inflammation generally; but it does not apply to the progressive advance of granular degeneration of the kidneys, the influence of which is, from first to last, to lower the specific gravity of the urine. So true indeed is this remark that, were an opinion as to the nature of the disease required to be formed from the specific gravity only of the urine, granular kidney would be at once suspected, provided the density stood at 1·008, or from that to 1·012. With the same precision and exactitude, diabetes mellitus would be strongly suspected, if the density of the urine reached 1·033; but its existence

would be rendered certain if, on taking the specific gravity of the urine, its density were found to reach 1·040; because no other disease with the occasional exception of chylous urine, ever raises the density of that secretion to this high degree. In fevers, both eruptive and non-eruptive, and in inflammation of the different organs, no sooner is the disease established than the urine increases in specific gravity; and it, as a rule, never again, from that moment to the termination of the disease, falls below its usual standard of health for each individual case. It may, however, have, between the period of the establishment of the disease and the termination in recovery or death, certain fluctuations, which have their significance, and which, when judged in connection with other indications, afford valuable information as to the grounds for prognosis; but to whatever specific gravity these fluctuations lead, the density of the urine is invariably as high as, and almost always higher than, that of the urine of the same person in health. This rise in the specific gravity is, in the first instance, due to the presence of an *increase of urea* and of the colouring matters of the urine; and, in the second instance, when the disease tends towards recovery, to the presence also of the urates of the alkalies in increased quantity. If the disease shows no disposition to terminate in recovery, then the continued increase of density is maintained throughout by the urea and colouring matter before named; but chiefly by the urea itself. If it fluctuates in its tendency between recovery and death—at one time showing a disposition to terminate in the former—at onother time, to end in the latter—the increased density is maintained throughout the two phases; but, in the former, it is due to the presence of urea and the urates—in the latter, chiefly to the urea as before described.

There is no disease in which the density of the urine fluctuates more than in pulmonary consumption. At one time it shall not exceed 1·007; at another time it ranges within the ordinary limits of health; again it equals 1·026-30. When the density is low, it is generally associated with pain in some part of the body, with abstinence from food, and with the ingestion of more than the usual quantity of fluid. Here the nervous excitement seems to increase the secretory action of the kidneys, the Malpighian bodies filter off a large quantity of fluid, and thirst is excited beyond the ordinary degree in such disease, to compensate, by an increased quantity of drink, for the augmented flow of urine thus produced Such instances are more common in the female than in the male

constitution, and in girlhood and adolescence than in adult life. When the density of the urine ranges within that of ordinary, healthy urine, it will be found to depend on an improved condition of the digestive organs and of the general health. Such improvement occurs only in the more chronic—never, or very rarely indeed, in the acute form of pulmonary consumption. It is a matter of well accorded observation, that dyspepsia often precedes, for some time, the deposit of tubercle in the lungs—that at one time it is better, and that at other times it is worse—that the weight of the body increases and decreases with these alternating conditions of the digestive organs—and that the density of the urine observes a similar ratio. In progressive cases the periods of aggravation outstretch those of improvement—the weight of the body has, at the end of a given period, greatly diminished—and the products of the imperfect digestion and assimilation of food, and the compounds resulting from the waste of tissue, being thrown upon the kidneys an increased density of their secretion is the result. Still, times and periods of improvement, however short, do occur, in which the digestion and assimilation of food are more complete, the body ceases to waste, and the density of the urine is diminished. During the period of pulmonary deposit there are certain phases or epoch, which mark the advent of fresh crops of tubercle; and certain periods of repose, which mark the temporary cessation of the localization of tubercle. The former are productive of urine of increased density—the latter, after a time, restore it to the patient's general standard of health. In the softening of tubercle and the consequent formation and subsequent extension of caverns, there is great waste of tissue, the organic compounds resulting from the breaking up of which and from the recombination of its elements, appear more particularly in the urine, the specific gravity of which is in consequence raised to 1·026-30. At this stage of the disease the urine generally maintains a high specific gravity, which is a sure indication of the progressive waste of tissue and of the certain and advancing step of death.

If we regard the urine in the acute forms of pulmonary consumption, we find that, as a rule, it manifests a high specific gravity from the commencement of the disease to its close. This density varies from 1·018 to 1·030, its more frequent specific gravity being 1·026-28. In this respect it closely approaches the density of the urine in local inflammations of an acute character; but its continuance is much longer than that of the latter. It is

also co-ordinate with the density of the urine in the last stage of chronic pulmonary consumption, when hectic fever has supervened, and when the lungs are undergoing rapid disintegration. It is, however, more persistently high in the acute than in the closing stage even of chronic pulmonary consumption; because there is, in the former, no cessation of those signs and symptoms which denote the constant advance of disease; whilst there is, in the latter, a daily fluctuation of indications which sometimes show a diminution in the severity, and consequently a partial abatement of the destructive action of the disease, under which the density of the urine falls. Given a case of pulmonary consumption, the daily observation of the density of the urine, for a short time, would enable the physician, without reference to any other indications, to determine whether or not the form of the disease was acute or chronic, and with what degree of rapidity it was advancing. If the urine passed at all times during the twenty-four hours were of similar specific gravity, and if that specific gravity were from 1·026 to 1·030, and if that density were found to be constant for ten or fourteen days successively, there would, from this simple fact alone, be no difficulty in pronouncing the case to be one of acute pulmonary consumption. If, on the other hand, the morning, midday, and night urine, varied in specific gravity; if, at one of these periods that specific gravity were 1·016; at another period, 1·020-22; at a third period, 1·026-28; and if these fluctuations were observed for ten or fourteen days in succession, the existence of chronic pulmonary consumption might, in such a case, with confidence be pronounced. By observing these fluctuations, and by noting their tendency or otherwise to approximate their densities in the one or other direction of the higher or lower degree of specific gravity which the urine had reached, the progress of a case may be determined. If, for instance, the specific gravity of the urine, after having manifested for a time the diurnal revolutions of density before described, tended throughout the twenty-four hours of day and night, to the highest degree of specific gravity already given, the certain indication would be—that the disease was progressing with a steady increase. If again, the specific gravity of the urine tended, under the circumstances of diurnal revolution just stated, to the lowest degree of density, and if it thus continued from day to day, it would show as positively that the progress of the disease had received a temporary check or abatement.

In diseases of the digestive organs, whether of an organic or of a

functional nature, as well as in other diseases in which these organs are wont to be greatly disturbed, as in gout and acute rheumatism, the specific gravity of the urine varies considerably. In dyspepsia the tendency of the affection is, to raise the specific gravity of the urine, because the food taken into the stomach cannot undergo that complete digestion which is necessary for the formation of healthy blood; and being, therefore, incapable of assimilation by the tissues of the body, it simply undergoes those transformations which direct its elimination by the kidneys, through which it passes more especially as the urates of the alkalies, and thus increases the specific gravity of the urine. In that form, however, of dyspepsia which is distinguished by the epithet "irritable," the specific gravity of the urine is often suddenly diminished. When such is the case, it follows pain of the stomach consequent on the ingestion of food, the excitement of which, being apparently transmitted through the great sympathetic to the renal plexus of nerves, rouses the secretory action of the kidneys, and thus induces an increased secretion of urine, the specific gravity of which is consequently below the natural standard.

In the early stage of organic disease of the stomach, as in scirrhus of that organ, the urine is generally either of the natural density or several degrees below it; but no sooner has the stage of ulceration arrived, than the specific gravity shows a tendency to increase. For this change an easy explanation is found in the fact, that the disintegration which, at this stage, is advancing in the walls of the stomach, and the, probably, consequent absorption of morbid matter into the veins—the powerful impression which is, by the presence of cancerous elements in the blood, made upon the structures of the body in diminishing their vitality, and in thus favouring their dissolution—and the effect of a diminished supply of food and of the imperfect digestion and assimilation of the very small quantity which the stomach is, at this juncture, able to retain, determine an increased amount of solids to the kidneys, through which, in their transformations into urea, uric acid and its resultant salts with ammonia, potash, and soda, as also into purpurine, pass off by the urine with a necessary increase in the density of that secretion. Hence the daily observation of the specific gravity of the urine would, in such instances, become, to a certain extent, the measure of the progress of the disease. This fact, true with respect to disease of the stomach, is no less true of the morbid affections of the liver. In hypertrophy, in cirrhosis, in cancer, in tubercle, in

abscess of that organ, when the resultant obstacle to the portal circulation has become well marked, the renal vessels become, not as a necessary consequence, but as a co-ordinate condition, turgid with blood surcharged with material, part of which ought, in the common course of healthy action, to be eliminated by the liver, but which, owing to disease of that organ, and to the consequent interruption to its function, is now cast out of the body by the kidneys, with the necessary effect of increasing the density of the urine.

Such, too, is the effect of any mechanical obstruction to the flow of bile from the biliary duct into the duodenum. Here, the obstructed action of the liver is, in the manner just stated, supplemented by a vicarious action of the kidneys, by which a portion of the bile is removed with their natural secretion, which thus acquires an increased density in proportion to the quantity of biliary matter present. Bile, per se, always increases the density of the urine; but the urine may contain bile, and yet its specific gravity shall not exceed the specific gravity which the urine itself would, under ordinary circumstances, have acquired without any admixture whatever of bile. This sometimes occurs in the passing of gall-stones, when the pain is not only severe, but more or less persistent for hours. The nervous excitement produced by the pain of an impacted biliary calculus, is reflected through the sympathetic nerve to the kidneys; their secretory action is thus inordinately excited; a large quantity of fluid is secreted; the bile being already prepared and existing as such in the renal vessels, is at once filtered off in preference, as it were, to the natural constituents of the urine; and thus, the increased density produced by the presence of bile being neutralized, or more than neutralized, by the more or less absence of the urinary solids, a urine, impregnated with bile, may be passed without its specific gravity exceeding, or, in some instances, even equalling, that of the urine of health. Such, however, is the exception to the ordinary result; and, therefore, the rule must always be—that the presence of bile in the urine increases the density of the latter secretion.

If we compare the influence of heart-disease with that of disease of the digestive organs on the density of the urine, we find that it is much less in the former than in the latter. When heart-disease is not producing any of the secondary results which usually flow from it, the density of the urine may remain natural for years. When it simply causes a gentle turgesence of the

renal vessels, without any show of dropsy of the lower extremities, or any portal engorgement, the urine is slightly increased in quantity, and either natural or slightly diminished in density; but when it offers to the blood returning to the right side of the heart a sufficient obstruction to cause a back-flooding upon the portal vein and its tributaries, and upon the inferior vena cava, the urine is diminished in quantity, but generally increased in density. Similar results, although somewhat different in degree, are associated with the existence of abdominal tumours. So long as these do not interfere with the natural functions of the abdominal organs, the density of the urine is uninfluenced by them; but when, from the growth which they have acquired, and from the consequent pressure and displacement of the abdominal organs, digestion is impeded, and the natural secretions are disturbed, the specific gravity of the urine exceeds its usual limits, and not unfrequently reaches 1·030. Tumours of a malignant character, from their more rapid growth, by which pressure and displacement are more suddenly brought about, and from the more depressing influence which they exert upon the vital powers, more readily and more quickly influence the density of the urine than tumours of a benignant character. I have seen a tumour, diagnosed as omental and harmless in its nature, exist for years with scarcely any increase of growth, and without influencing, in the slightest degree, the urine in either its quantity or specific gravity. Mesenteric tumours, on the contrary, which are often malignant, frequently grow rapidly, and by their influence on the digestive organs and on the circulatory system of the abdomen, render the urine, even from the moment of their possible detection, of higher specific gravity than that of the healthy secretion; whilst ovarian tumours may continue to grow for months, and may even attain a considerable size before the urine is at all effected in its density. Hence, in a case of abdominal tumour surrounded by doubtful symptoms, the diagnosis may be assisted by closely watching, for a short time, the density of the urine.

It has been already stated, that gout and rheumatism greatly influence the specific gravity of the urine. Under their influence, in their acute character, the density often reaches 1·030, below which it seldom falls further than 1.026 until the attack ends in convalescence. In muscular rheumatism and in masked gout, in which there are flitting pains and but little disturbance of the general system, the density of the urine varies considerably. At

one time, when pain is more urgent than usual, there is diminished density with increased quantity of urine; at another time, the urine is of ordinary specific gravity and quantity; and again, on other occasions, the density rises to 1·028 or 1·030. The last mentioned density must always be accepted in a favourable light; because it shows that the kidneys are eliminating from the blood those morbid elements upon the presence of which in the tissues the gout and rheumatism depend.

COLOUR OF URINE IN DISEASE.

It has been shown that both the quantity and the density of the urine are greatly influenced by the different diseases to which the human body is liable. It is no less true, that the colour of the urine is, in like manner, affected by disease. To appreciate the changes which it undergoes in this respect, it is necessary to have a proper conception of what, under the ordinary conditions of life, constitutes the standard of colour in healthy urine. Now, the basis of the natural colour of healthy urine is yellow, or what is understood by the term—straw-colour. Of this, three shades may be recognised — the light, the moderate, and the deep yellow. Through all these shades the urine, in health, presents a bright sparkling appearance, which is due to the reflection of light from its surface, and to the refraction of light as it passes through the fluid. The less the quantity of light absorbed by the urine the brighter is its colour; and, on the contrary, the greater the quantity of light absorbed by it, the duller and deader appearance does it present to the eye. This latter condition is due to a giving way of those molecular forces which hold the organic atoms of the urine in vital bond; or, in other words, it is expressive of commencing decay in such atoms. This change is attended by increased absorption, and by diminished reflection and refraction of light, thus causing a duller appearance to be given to the urine. To speak, then, of the vitality of the urine after its emission from the body, would be but a co-ordinate term with that which expresses the vitality of a muscle from the period of somatic death to its organic disruption by chemical change. The body dies; for a certain period afterwards the muscles contract under the application of galvanism as they did in life under the stimulus of the will. This is the expression of an inherent vitality in the muscles themselves. It is in fact organic life, which remains for a time

with the body, after life, in its more spiritual conception, has passed away. Putrefaction at length commences; the muscles become soft and diffluent; their fibrillæ break down; they lose their organization; they can no longer respond to the stimulus of galvanism; their organic life is at an end. In like manner, and for similar reasons, there is for the urine, after its emission from the body, a period in which it undergoes no change. Its physical properties, its organic constituents, its chemical re-actions continue for a time unaffected, uninfluenced by those chemical agents which are continually destroying inanimate organized matter, and as continually rearranging and recombining its elements in other forms. Does not this period of the maintenance of the urine's integrity depend on an inherent vitality in its organic constituents? These at length give way; they are broken up and resolved into their ultimate elements; these elements are recombined and thus form compounds foreign to the natural constituents of the urine; the physical properties of the urine are thereby altered; its chemical action is changed; its integrity is destroyed; it is, in fact, no longer urine, but a putrid, fœtid, dead, disorganised fluid. Let us, then, carry with us the idea of life in the urine, and it will assist us in explaining the optical changes which are produced in it by disease.

Now, from the standard of colour which has been fixed for healthy urine, there are two divergences which are produced by disease. The one has reference to a deeper—the other, to a lighter colour than that of the urine in health. Each has its particular significance in reference to diseases of which it is a consequence. This significance must be sought and determined, in order that the knowledge thus obtained may have its practical application to diagnosis and to the therapeutics of disease. Taking the lowest standard colour of healthy urine for comparison, we find that some diseases cause the colour to diverge from such standard to the condition of almost a colourless fluid like water. What, then, it may be asked, are the diseases which produce this effect on the urine? Experience teaches us, that they are the purely nervous—diseases also, which, during their course, either temporarily or permanently affect the nervous system and, in many instances, the digestive organs as well—and diseases of the kidneys themselves. The modus operandi is not the same in the different diseases which produce a pale urine, although the result in all may be more or less uniform. In one class of diseases

producing pale urine the want of colour is due to the presence of an excess of water—in another class, to a relative deficiency of the natural solids of the urine, of which the colouring matter is one—in a third, to both of these causes combined. The urine of neuralgia, of hysteria, and of cranial rheumatism, illustrates the first—the urine of degenerated kidneys the second—and the urine of chronic diabetes mellitus the third. These have one character in common—that of a pale colour, almost as light as water; but here their analogy ends. They are widely different as to their densities; they are different in their chemical constitution; and they differ as to their pathological cause. The urine of neuralgia and of hysteria may have a specific gravity of 1·002-7 only—that of degenerated kidneys 1·010-12—that of chronic diabetes 1·045-50. The chemical analysis of the first shows a deficiency only of the natural solids—that of the second, an impregnation with albumen, with a less deficiency of the natural solids—that of the third, the presence of sugar with or without, but generally with, a reduction of the natural quantity in the urinary solids. Again, in the first, the pathological cause is mere nervous disturbance of the kidneys—in the second, absolute disease of the kidneys themselves—in the third, irritation of the floor of the fourth ventricle of the brain according to Bernard; a perverted action of the liver, by which its glucogen is converted into sugar according to others. What, then, is the practical inference to be drawn from these facts? It is this—that pale urine is not diagnostic of any particular disease. Let the physician, then, be careful how he, on being shown a quantity of pale urine, expresses an opinion as to the nature of the disease from which his patient suffers. The specific gravity must be noted; albumen and sugar must be sought by the usual tests; the microscopic appearance of the sediment, if any, must be examined; the quantity of urine secreted within a given time must be ascertained; the colour must be noted; and all these must form elements of calculation in attempting a diagnosis from the mere character of the urine itself.

But there is another condition of the urine, in which that fluid is pale, and in which it differs from the other examples of pale urine already given. It approaches, although faintly, the lightest shade of the standard colour of the urine, with a dash of white, as though a few drops of milk had been distributed through it; its specific gravity ranges from 1·010 to 1·024; it has an acid reaction; and lets fall a curdy precipitate on being

boiled, which precipitate is immediately dissolved on the addition of nitric acid, rendering the urine very clear with the merest tint of bistre in it. Such urine is distinguished by the epithet, phosphatic. If the sediment is allowed to subside, it collects at the bottom of the containing vessel like flocculent snow, and displays under the microscope beautiful prismatic crystals—separate, in groups, in stellary tufts, and often interspersed with octahedra of oxalate of lime. This urine differs from all the preceding examples of pale urine in colour, in specific gravity, in chemical constitution, and in its pathological cause. It is expressive of either functional disturbance or organic lesion of the nervous centres. It is frequently the result of wear and tear of the nervous system. If it occurs in a clergyman, statesman, or person given to deep study, look for the cause in over-exertion of the mind; if in a tradesman, ask about losses in business; if in a young female, interrogate the affections, and you will almost invariably find its cause either in the grief of unrequited love, or in the sorrow and anguish of mind produced by the loss of a dear, departed one. But it does not always occur as a primary result. It occasionally takes the character of an intercurrent affection, variable in its duration, often fugitive, often recurring, and often replacing, for the time being, some constituent of the urine caused by the primary disease. Thus I have seen it occur in the urine of diabetes mellitus of a few months' duration, in which it would appear for a few hours, then disappear for a day, to reappear again and again at short intervals. Its occurrence was invariably marked by the suspension of the excretion of sugar, and its disappearance was immediately followed by the reappearance of sugar in the urine. Occasionally, sugar, phosphate and oxalate of lime, and uric acid in crystals, alternated with one another; and again, the sugar and uric acid existed together—a circumstance of not uncommon occurrence in those cases of diabetes which are not of long standing, in which the quantity of urine is but little in excess, and in which the urinary solids have undergone little or no reduction.

Under this aspect of colour, as to the urine, may be mentioned two conditions, which give to that fluid, on its emission, a more or less milky appearance. The one is where chyle, the other where pus, is present in the urine. In the former, which is of extremely rare occurrence, and which is far more frequently found in warm climates than in temperate latitudes, a quantity of fat in a molecular form, together with albumen, and sometimes with fibrine,

blood-globules, and fatty epithelium from the tubuli uriniferi, is disseminated through the urine. To the action of the alkalies of the urine on this molecular fatty matter the milky appearance of that secretion is probably due. This is removed by an excess of ether, which, by dissolving the fatty matter, renders the urine clear. Sometimes the urine is clear on being voided, but, on standing, coagulates into a jelly-like mass. At other times, whilst manifesting its distinctive character of milkiness, it on cooling assumes a solid form. In the former instance but little fat is present in the urine; whilst there is the usual amount of albumen in such cases. In the latter, both fat and albumen exist in the proportions usually found in this disease. This condition of the urine may or may not be associated with degeneration of the kidneys. When it is not, there is an absence of renal epithelium, casts of the tubuli uriniferi, and blood-globules from the urine. When it is, these almost necessary products of renal disease are superadded to the essential constituents on which the milkiness of the urine depends. It is a notable fact that, during the existence of this affection, the urine is not always in the same individual milky in appearance. At one hour of the day it presents this character; at another, it is quite clear; whilst, shortly afterwards, it returns to its speciality of colour. This colour may be assumed by the urine shortly after a meal, to continue through the day, and to disappear from the urine at night; or it may be present in the urine of the night and of the early morning before food, to disappear after breakfast, and to continue absent during the remaining hours of the day. To what pathological cause are we to refer this milkiness of the urine? It has been known to exist where no trace of disease in the kidneys could be found. It is thus shown to be independent of any affection of those organs. It, on the contrary, is always associated with more or less of malaise, with a falling off in the general health, and with loss of strength. Hence, the probability is—that primary assimilation of the food is not perfected—that chyle passes into the blood without undergoing its usual conversion in the lungs—that the kidneys, as the chief excretory organs of matter foreign to the welfare of the body, take cognisance of its presence in the renal vessels—and that these, partaking of the general relaxation of the vascular system, and indeed of every structure, arising out of the general debility which exists, allow the fatty matter in question, and, with it, a portion of albumen, to filter through their walls, to escape into the tubuli uriniferi, and

to pass off with the urine, to which it gives the peculiar milky appearance already described. What, then, does this view of its pathology inculcate? That, in all such cases, minute regard should be had to the state of the digestive organs, to those circumstances of life which influence them, to the condition of the respiration, and to the state of the kidneys, not in the relation of necessary, but in the light of accidental, disease with which they may be affected. But it does more than this. It further teaches that, in the absence of kidney disease, there exists no pathological cause why the disease should not be cured; but that, where any complication, like that of degenerated kidneys, exists, it is impossible for the patient to recover.

When pus is present in the urine, the latter fluid, although milky in its appearance at the moment of its discharge from the bladder, becomes on standing separated into a supernatant fluid which is clear, and a white sediment, which is seen, under the microscope, to consist of the characteristic pus corpuscles. Now, the existence of these cells in the urine is diagnostic of inflammation of some portion of the genito-urinary mucous membrane. If it occurs in the male in pretty large quantity, the pelvis or the tubuli uriniferi of the kidneys are the probable seat of disease. If it has its origin in the bladder, it is associated with a quantity of thick, viscid mucus, which clings to the bottom of the containing vessel, which, on the inversion of the latter, it quits in one thick, glairy, tenacious, ropy mass. It may, however, have its origin in the bladder without there being any admixture of mucus. This generally occurs when a catheter is left in the bladder for some time; or when the bladder has been kept in a state of more or less distension for weeks by stricture of the urethra. When purulent urine follows the retention of a catheter, the last portion only of the urine drawn off is milky; but when the bladder has been partially distended for some time, and when it is relieved for the first time by the catheter, the urine is more or less milky throughout the whole period of its flow. In acute gonorrhœa the admixture of pus with the urine as the latter flows along the urethra, communicates to the urine only a very faint milky appearance, which is due to the comparatively small proportion of pus which is present. These facts, as regards the male, establish two great points of diagnosis. The one is—that a milky-coloured urine, letting fall a large deposit of pus only, points to suppurative action of the kidneys; the other—that where, with pus, there is such an

admixture of mucus in the urine, that the deposit forms one, thick, glairy, ropy mass, which clings to the bottom of the containing vessel, the lining membrane of the bladder is the seat of disease.

In the female the colour of the urine may be rendered milky in appearance, not only from the causes just mentioned, but also from inflammation of the mucous membrane of the vagina and uterus. This affection is productive of a purulent discharge, which is more common in the married than in the single, which is sometimes profuse, but which is more frequently moderate in quantity, and consequently insufficient to impart more than a slight milkiness to the colour of the urine.

If we now ascend the scale of colour, we find that, in passing from the lowest to the highest standard shade of healthy urine, we approach that of oxaluria. The colour of the urine in this affection is generally of a deep amber—several shades deeper than the deepest colour of healthy urine; but it is also occasionally of a pale straw colour, similar to that which has been the subject of the previous remarks. When with the deep amber colour, the density ranges from 1·025 to 1·030; and when with the lighter colour, the density varies from 1·015 to 1·022; and when, moreover, there are, in the subject of it, great depression of spirits, irritable dyspepsia, pain across the loins, loss of flesh, and considerable prostration, the urine should be examined for oxalate of lime. Such a urine is so frequently the concomitant of great mental exertion, of the continued devotion of the mind to business pursuits, and of the worries and anxieties of professional life, that its existence should be suspected in clergymen, barristers, literati, merchants, and others, who present the general indications above stated.

In still further ascending the scale of colour we come to that which may be termed yellowish-red and brownish-red urine. This is essentially the urine of active inflammation. Between these two extremes there are other degrees of shade through which the urine passes from the acme of inflammation to its decline. These degrees are well worthy of study, inasmuch as they afford valuable information as to the intensity of the inflammation and the progress which it is making either in the direction of recovery or of death. When a local inflammation of an intense character has been established, the urine becomes of a brownish-red colour, is quite clear, has an acid reaction, and is of the specific gravity of 1·028 or 1·030. If the inflammation is less intense, the urine is a few shades lighter in colour in the direction of yellowish-red, and

manifests a specific gravity of 1·026 or 1·028. If the inflammation is still less in degree, although acute, the urine is yellowish-red in colour, and 1·025 or 1·026 in density. In all these instances the urine remains quite clear for an indefinite number of days after being voided—generally, however, from three to five or six—when it lets fall a sediment, flocculent in appearance, and consisting of the urates of the alkalies. Whichever of these shades the urine presents on the full establishment of inflammation, that shade it continues to manifest so long as the inflammation exists in all its severity; but no sooner does the inflammation decline, in the least degree, than the depth of shade in the urine becomes somewhat lighter. By attentive observation we shall often find that this slight change of colour in the urine is the very first noticeable indication of an improvement in the disease. If all other symptoms continue in all their original severity, this change may be accepted as a sure indication of the tendency in the inflammation to subside. It does not, however, follow from this, that the tendency thus expressed will continue. Various causes may arise in the system, by which the inflammation is again aggravated; but with this aggravation the urine invariably loses its improved shade of colour, and again acquires that of its original brownish-red. When, however, the tendency to improve continues, the urine becomes lighter and lighter in shade, reaches a yellowish-red, and thence continues to pass by changes of shade until it acquires the deep yellow or straw colour of healthy urine. The depth of colour of inflammatory urine is due to an excess of the pigment matter of this secretion, and its increased density to the presence of an increased quantity of urea. When such urine begins to lighten in shade *the urea also declines in quantity;* but *the uric acid increases.* Hence, in inflammatory urine, uric acid replaces to a certain extent urea in the declining phase of the disease. This fact is opposed to the views of Liebig, who regards urea as the derivative of uric acid formed from the direct metamorphosis of the nitrogenous tissues. But facts are more reliable than theory; and facts prove that, during the persistence of inflammation, the urea exists in increased quantity in the urine—that as soon as the inflammation begins to decline the quantity of urea becomes less—and that at this moment the uric acid is increased. Now, as the exudation of inflammation consists, like the nitrogenous tissues of the body, of protein compounds, we should expect that, according to the views of Liebig, the metamorphosis of such exudation would first result

in the production of an increased quantity of uric acid, and then in the conversion of the latter into urea, which would thus appear in increased quantity in the urine, and with a reduction of the uric acid at the close of the disease. Hence, the urates ought not, according to this view, to appear in the urine at the termination of an inflammation, but urea in increased quantity. Now, this is precisely the reverse of what really happens. The views of Liebig on this question are therefore untenable; whilst the physiology of clinical facts seems to justify the view, that, in the metamorphosis of the albumen and fibrine of an inflammatory exudation, these protein compounds are first converted into urea, and afterwards in part into uric acid and ammonia, which, as urate of ammonia, constitute the sediment so constantly observed in the urine during the subsidence of local inflammations. But, to revert to the question of the colour of the urine in inflammation, there are several points which assist us in our prognosis. If, in the progress of inflammation, the urine continues of the same depth of colour as it presented on the full establishment of the disease, we know that there is as yet no improvement in the case; but if, on the contrary, the symptoms have increased in severity, and the urine nevertheless presents a bright, clear, sparkling appearance, notwithstanding any increase of depth of colour which it may have undergone from the aggravation of the disease, hope of improvement may still be entertained. Again, it may be stated—that if, without there being any perceptible increase in the severity of the disease, the urine should lose its clear, bright, and sparkling character, and if it should present a dull, dingy, and dead appearance, the condition of the patient may be unhesitatingly pronounced to be worse. Such a change in the urine does not necessarily imply that the patient will die; but it expresses a condition in which there is a tendency to death, and which ought to have its weight both in the prognosis to be given and in the treatment to be pursued. It is due, as has been before shown, to an alteration in the molecular arrangement of the organic matter of the urine in its first steps of decay, under which more light is absorbed, and less reflected and refracted, in its transmission through that fluid.

Now, the colour of the urine which has been given as that which is the associate of inflammatory action, is also a consequence of those diseases which are characterized by an augmented temperature of the body. Hence, in the different forms of fevers, the urine, under the full influence of the disease, is either of a yellowish-red

or brownish-red colour—the lighter shade being generally associated with fever of a milder form, and the deeper shade with fever of a more severe type. The duration of their continuance is governed by the particular type of fever which is present. In simple inflammatory fever they continue only during the urgency of the disease, which may last from one to three or four days; in eruptive fevers, during the growth and the acme of the eruption, after which the colour of the urine tends, under favourable circumstances, to the healthy standard. If at these particular times the urine does not become lighter in colour, a persistence of fever is to be apprehended. If, on the contrary, the urine has deepened its colour, and if it remains clear on cooling, an intercurrent inflammation is either existing or at hand. Although the yellowish-red and brownish-red colours are the characteristic colours of inflammatory urine, yet it must not be forgotten that these colours are particularly modified by acute inflammation of the kidneys and of the liver. In the former, the extreme congestion of the renal vessels arrests, in a great measure, the natural function of those organs, and causes, by continued pressure upon the vascular walls, an escape of blood into the tubuli uriniferi, along which it is washed by the urine, to which, as seen when voided, it imparts a smoke-brown colour. The existence of this kind of urine should always induce the physician, on being called to a patient, to enquire into the condition of the kidneys. Led by the particular colour of the urine, he will enquire into the specific gravity of the latter, the quantity of urine secreted, its behaviour under the application of heat and nitric acid, the microscopic appearance of the sediment which subsides in the urine on repose; and he will further ascertain whether vomiting, which is a frequent symptom of acute nephritis, exists; whether there is any puffiness of the eyelids or of the ankles; what is the condition of the loins as to pain; and whether or not a febrile condition of the system is present. Attention to these points will enable him, without hesitation and without the risk of error, to pronounce upon the state of the kidneys. In the latter disease—*i.e.* inflammation of the liver—the generally inflammatory colour of the urine is marked by the presence of the colouring matters of the bile. Here, as in the case of the kidneys, the extreme congestion of the hepatic vessels arrests more or less the function of the liver, and throws back upon the blood the biliary elements, which are in part directed by the conservative action of the system to the kidneys, through which they pass with

the natural secretion, and appear in the urine, to which they impart a yellowish, or greenish-yellow, or brownish or blackish-yellow, colour, according to the quantity of bile which is present. The occurrence of such urine in a patient ought at once to direct the attention of the physician to an examination of the liver.

In still further considering the question of the colour of the urine in relation to disease, the attention is arrested by that of the colour of the urine in acute rheumatism. In this disease the colour of the urine is of a deep lake red, or brownish-red, which, at first sight, may convey the impression as though a certain quantity of blood were mixed with the urine. Such urine has an acid reaction, is generally of the specific gravity of 1·028 or 1·030, and lets fall on cooling a heavy sediment of the urates deeply stained with purpurine. Purpurate of ammonia is also present to such a degree that a pink circle of it is deposited around the bottom and sides of the containing vessel. It is from the presence of this constituent that the urine acquires in acute rheumatism the peculiar colour just stated. In other forms of rheumatism, and especially in that form which seems to centre itself in the nerves of a part, this highly coloured urine not unfrequently occurs. The remembrance of this fact may at times serve to elucidate and to explain the character of a pain, of the nature of which some doubt may have been felt. Let me illustrate by a case. A patient is seized with a pain in the side or in a particular part of the abdomen; it is fixed and constant; pressure or motion aggravates it; but the general disturbance of the system is so slight that there is no increased heat of the skin—no thirst—no interference with the appetite. The pain, however, continues; it is still fixed; the affected part has become more painful on pressure or motion; there is no thirst; still, the appetite is not as good as it was; the tongue is a little furred; but the urine is natural. Very shortly afterwards the pain ceases rather suddenly, or it remits for a short time and then ceases; the urine next voided is of a brown-red colour; and a sediment of a lake colour forms in circles at the bottom, or entirely covers the bottom, of the containing vessel Again—pain of a similar character attacks the bowels or the bladder; there is as before an absence of general symptoms; but with the pain in the bowels there is by-and-bye a tendency to diarrhœa; and with pain in the bladder a rather frequent desire to micturate, accompanied by a constant sense of uneasiness behind the pubes; whilst the attack in both instances terminates with the

deposit of a pink sediment in the urine. Now, the presence of this deposit may be accepted as a sure sign that the pain in question was rheumatic in its character. But this deep lake coloured urine is not confined to rheumatism alone; therefore its presence must not be regarded as pathognomonic of that disease. In organic and other diseases of the liver, as well as in delirium tremens, it is likewise of very common occurrence; and in diseases of the lungs and of the heart it is not unfrequently seen as a morbid constituent of the urine. When, however, its presence is associated with heart disease, it is, in my opinion, more dependent on the rheumatic constitution in which the heart disease finds its probable cause, as well as on a perverted function of the liver produced by the back-flooding from the right side of the heart, than upon the heart disease itself, simply considered as such. In other affections than these it seldom occurs. Hence, its existence in the urine is at all times suggestive of rheumatism, of hepatic disease, of delirium tremens, of affections of the lungs, and of disease of the heart; but the question, as to which of these organs is, in each particular instance, at fault, must be determined by reference to other symptoms and special indications.

AËRABILITY OF THE URINE IN DISEASE.

There is one physical condition of the urine in disease, which has commanded but little attention, but which nevertheless is well worthy of notice. It is the capability of the urine, on being shaken in a bottle, to maintain the frothy head caused by air imprisoned in the form of bubbles on its surface. The duration of this capability varies in the urine of certain diseases. It does not depend upon the density of the urine; but it is owing to the presence of substances which are chiefly foreign to the natural constitution of that fluid. At the head of such substances stand sugar and albumen. When urine containing either the one or the other of these substances is shaken in a bottle which is afterwards kept corked, the head of the air-bubbles thus produced will not entirely break and subside for upwards of twenty-four hours. Saccharine urine manifests a greater capability of maintaining these bubbles than does albuminous urine. Hence, diabetic urine possesses the property of aëration in the greatest degree; next the urine of diseased kidneys containing albumen; then urine containing bile, and the urine of fever in which albumen is present; after which the capability of

aëration may be said to depend on the quantity of urea which is present in the urine. We thus come to the urine of the first stage of inflammation, in which the quantity of urea is greater than in any subsequent stage of the disease, and in which the aërability of the urine is in consequence proportionately greater than in the latter. Where the urine of disease contains no other than the ordinary constituents of that fluid, the capability of aëration is in proportionate ratio to the quantity of organic matter present in the urine. This organic matter, as well as sugar and albumen, imparts to the film, which encloses each air-bubble, a cohesion, which enables it to resist the expansive power of the air within it, and, when the fluid is exposed to the atmosphere, the pressure of the latter upon its surface, in a much greater degree than the film of a mere bubble of water in which no such organic matter or substance is dissolved. If, at the time of the emission of the urine, the vital forces of this organic matter are beginning to diminish, and if, in consequence, the complete disruption of its molecules is impending, the film with which it surrounds the bubbles of air is less cohesive, and consequently the bubbles themselves are less persistent, than those which are formed by the shaking of urine in which its organic constituents have as yet undergone no molecular change. This fact teaches us, that a daily comparison of the aërability of the urine in disease would at times afford valuable aid to the physician in forming a prognosis, But the comparison, to have this desired effect, must be made between specimens of urine of the same temperature; because the difference of a few degrees only of heat will cause the air of the urine of a higher temperature to become more rarefied than the air of the urine of a lower temperature, the consequence of which is—that an increased pressure is made upon the walls of the containing air-bubbles, and thus their disruption is more quickly brought about. It is also necessary, for the proper carrying out of this comparison, to take equal quantities of the different specimens of urine, as well as bottles of equal size; because, if it were not so, the difference of pressure upon the external surface of the bubbles would cause an earlier disruption of those in which the capacity of the bottle was greater, or the quantity of urine smaller, than of those in which these conditions were in the opposite direction. It is even further necessary, in order that comparative differences may be correctly estimated, that the different specimens of urine should be shaken through equal times. If such were not the case, it is manifest that, on one

urine, a large head of air-bubbles would be produced; whilst, on another urine, a small head of bubbles would be generated; and as, under equal conditions, the larger quantity would occupy in their subsidence a longer time than would the smaller quantity, a palpable error as to duration would necessarily arise. The best method of determining this point probably is—to put two ounces of each specimen of urine into separate bottles, each of which is capable of holding six ounces of fluid—to shake each bottle a sufficient length of time to cause a head of bubbles which shall occupy the whole of the remaining space of such bottle—and afterwards to note, in each instance, the time occupied in the complete subsidence of the bubbles.

URINARY SEDIMENTS IN DISEASE.

It has already been shown how disease modifies the urine in its quantity, density, colour, and acrability; how great is the knowledge which may be acquired by watching these changes; and what special significance that knowledge has, in reference to prognosis and treatment. But, however important such knowledge may be, it is not of more consequence in urinary pathology than the study of the sediments which occur in the urine during the different diseases which afflict the human body. To none of these sediments does more importance attach than to those which are known as the urates of the alkalies. To these and to uric acid separately considered, in relation to disease, I confine myself on the present occasion. Of these sediments there are two sources only as connected with the body. The one is—the food taken into the body —the other, the tissues of the body itself, or that portion of blood thrown out under disease, which would, in the ordinary course of nutrition, have been converted into the bodily structures. When, then, these deposits occur in the urine, it is important to know from which of these two sources they arise, and what is their special importance in the particular case under examination. Now, with respect to the food, as a source of uric acid and its combinations as alkaline urates in the urine, it is from the nitrogenized portion that these are derived. This portion of the food may either be in excess of the natural requirements of the system, or the digestive organs may be unequal to its perfect digestion. In the former instance, the surplus aliment undergoes a metamorphosis, by which its protein compounds are broken up, and afterwards re-

arranged and combined in the form of urea, which thus appears in excess in the urine, to which it gives a high specific gravity. This condition generally occurs where the digestive organs are in a healthy state and the nitrogenised food exceeds the demands of the body. Such a urine remains clear for some time after becoming cool, and does not generally deposit a sediment until from two to five or six days after its emission. This deposit presents both the chemical constitution and microscopic character of the urate of ammonia. Whence, then, has this urate of ammonia its origin? Let me appeal to facts for an answer. An ounce of fresh urine, directly after its emission from the bladder, was submitted to examination, and was found to contain 12·48 grains of urea. The sample of urine, from which this ounce was taken, was set aside in a well corked bottle. After standing five days it deposited a sediment of urate of ammonia, and gave, as in the first instance, an acid reaction to test-paper. Another ounce of this urine was now submitted to examination, and its quantity of urea was found to be 10·08 grains, thus showing a loss of 2·40 grains of urea during the five days in question. Again, it was found that, co-incident with this reduction of urea, there was an increase in the quantity of uric acid. Thus in the same sample of urine the quantity of uric acid was, in the first instance, found to be ·30 of a grain per ounce, which was increased to ·50 of a grain per ounce by the end of the fifth day, when the urine had deposited a sediment of urate of ammonia. If we appeal to the urine of disease we still find a confirmation of these facts. Thus, in a case of acute peritonitis, a specimen of urine, examined immediately after its emission from the bladder, contained 16·32 grains of urea per ounce; whilst the same specimen, after standing two days, during which time it deposited a rather copious sediment of the urates, yielded only 11·52 grains of urea per ounce. Co-incident with this reduction in the quantity of urea the uric acid increased from 1·10 grains per ounce in the first examination, to 1·85 grains per ounce in the second examination, which was conducted at the expiration of the two days in question. To what explanation do these facts point? Evidently to the following—that the urea contained in both healthy and diseased urine is, from the time of the emission of the urine from the bladder until it passes into putrefactive decomposition, convertible, and is in part converted, into uric acid as one of the derivatives of the transformation which the urea undergoes. It would thus appear that before actual decomposition converts the urea into

carbonate of ammonia, the molecular forces which maintain the unity and integrity of urea give way—that a part of the urea is thus resolved into its ultimate elements—and that the re-arrangement of these elements results in the formation of uric acid and ammonia, with the liberation of oxygen. Hence, as is shown by the following formula, five atoms of urea are convertible into one atom of uric acid, six atoms of ammonia, and six atoms of oxygen.

	C	H	N	O
One atom of uric acid	10+	2+	4+	4
Six atoms of ammonia		18+	6	
Six atoms of oxygen				6
=Five atoms of urea . . .	10+	20+	10+	10

During the occurrence of these changes the mucus, always present to a slight extent in healthy urine, may likewise undergo transformation, by which it is converted into lactic and acetic acids, which displace the uric acid from its combination with the fixed alkaline bases, and thus permit it to unite with a part of the ammonia formed from the urea, and to appear as a sediment in the urine. The practical inference to be drawn from these views teaches, that, in the absence of disease, a urine of high specific gravity (1·026-30), perfectly clear at the natural temperature of the atmosphere, and remaining so for several days after emission, abounds in urea—that the latter is due to an excess of nitrogenized food—and that the digestive functions are healthy.

Where the digestive organs are unequal to the perfect digestion of nitrogenized food, the latter is not so generally converted into urea as in the former instance; but it, on the contrary, is broken up, and its elements are re-arranged as uric acid and ammonia, which, as urate of ammonia, subside in the urine on its becoming cool after emission. Here again, the practical inference is that, in the different forms of dyspepsia, in which urate of ammonia appears as a sediment in the urine, this sediment is derived directly from the nitrogenized food—that such food does not necessarily exist in excess—but that its conversion into urate of ammonia is owing to defective digestion and assimilation.

When uric acid and the alkaline bases occur in the urine as the product of the disintegration of the tissues of the body, it is the result of either excessive muscular exertion or disease. In all acute diseases, attended by increased vascular action and by

general febrile movement, there are periods in which the deposit of urates invariably occurs in the urine. In fevers, in local inflammations, in acute gout and rheumatism, and in pulmonary consumption, this deposit is the product of such diseases, and it has in consequence a significance which should be properly understood. In the eruptive fevers of scarlatina, rubeola, and variola, it does not, as a rulo, appear in the urine until the eruption has reached its height and is beginning to decline. In typhoid and typhus fever there is reason to believe, that its appearance in the urine is co-incident with the fading of the petechiæ and maculæ characteristic of these fevers; and, in the case of typhoid or enteric fever, with the commencement of the absorption of the morbid deposit found in Peyer's glands; in erysipelas, with the cessation of exudation and its commencing metamorphosis; in local inflammations, with the absorption and removal of the inflammatory products from the affected organs; in acute gout and rheumatism, with the removal of morbid products from the affected joints; and in pulmonary consumption, with changes which are constantly occurring in and around the tuberculous deposit. It will thus be seen, that the appearance of a urate deposit in the urine is generally indicative of a tendency to recover; or it at least shows, that nature is making a strenuous effort to rid herself of the incubus of disease. The former part of this statement is true in its application to fevers, inflammations, and acute gout and rheumatism; whilst the latter part is applicable, and that only in part, to pulmonary consumption. Whilst, then, the deposit of urates must be accepted as a favourable sign in the former diseases, it is often, in pulmonary consumption, but the measure of the disintegration of tissue produced by disease. In the one it constitutes a favourable omen; in the other, the too frequent evidence of wasting life and impending decay.

In all organic diseases in which the general health is being undermined, urate deposit in the urine has the same unfavourable significance as in pulmonary consumption—it denotes the waste of tissue rather than the removal of adventitious products. Under certain conditions, however, it may nevertheless, even in organic diseases, become the measure of improvement. This is the case when an intercurrent inflammation has arisen, and been subdued, and when, in consequence, the metamorphosed exudation appears in the urine in the character of the urates. Thus far, but thus far only, have the urates a favourable significance in organic disease.

They indicate the cessation of the intercurrent inflammation and of the removal of its products; but they continue after these occurrences have taken place, and they then again become an exponent of the destructive action of the original disease. Their duration in the urine is capricious in all diseases except those of an acute or inflammatory type. In acute inflammations they continue in the urine, all things being equal, until the products of the inflammation have been removed from the tissues of the organ attacked. Difference of organ makes no difference in their constitution. They are the same in meningitis, cerebritis, bronchitis, pneumonia, hepatitis, peritonitis, and all other inflammations. Hence, the urates are essentially the urinary sign of the metamorphosed exudation of all inflammations. Their chemical constitution is not affected by the particular organ which suffers; but their relative continuance is modified or influenced by the particular organ or structure which is affected. Thus they have a longer duration in the removal of the products of inflammation from closed sacs, as the pleura and peritoneum, than in the removal of inflammatory products from structures having openings on the surface of the body, as the mucous membranes. Hence, urate deposits occur in the urine for a longer period during the absorption and removal of an exudation from the pleural cavity than from the bronchial membrane—from the cavity of the peritoneum than from the mucous membrane of the bowels. In both instances the quantity of urates which is cast off may be the same within a given time; but the time itself is longer in the one than in the other—in the case of pleuritis or peritonitis than in that of bronchitis or muco-enteritis. The reason of this difference appears to be—that all the exudation of pleuritis or peritonitis must, in consequence of the pleura and peritoneum having no *direct** outlet or communication with the surface of the body, be absorbed into the blood, and be by it carried in part to the kidneys in its removal from the body; whereas a part of the exudation of bronchitis and of muco-enteritis is at once expelled by the affected membranes themselves, and thence conveyed direct from the system, the effect of which is, to lessen materially the quantity of exudation to be absorbed, and consequently, to render the time occupied in its

* The fact that the peritoneum communicates with the surface of the body by the Fallopian tubes, uterus, and vagina, does not here affect the argument which regards it as a closed sac, so far as it influences the removal of morbid products from its cavity.

absorption of shorter duration than that of pleuritis or peritonitis. As the absorbed product of inflammation undergoes the necessary transformation, and is for the most part removed from the blood by the action of the kidneys, it follows, that the duration of the deposit of urates in the urine will be equal to the period of the absorption of the exudation; and, as this is shorter in the case of bronchitis or muco-enteritis than in that of pleuritis or peritonitis, in consequence of the direct expulsion of a part of the exudation in the former and not in the latter, so also the continuance of the deposit of urates in the urine is longer in the latter than in the former of these inflammations. For similar reasons, the breaking up and removal of the exudations of inflammations of the parenchyma of organs produce a longer period of deposit in the urine than the metamorphosis and expulsion from the body of the exudation of bronchitis or muco-enteritis. In acute diseases of the skin, as in eczema, herpes, ecthyma, and scabies, where the eruption is sufficiently extensive or sufficiently irritable, to arrest in part the natural action of the skin, and to excite the mobility of the nervous system, as well as to disturb more or less the balance of the circulation, the urates are generally deposited in the urine. When, however, skin diseases have existed for some time—when they have ceased to disturb, to any great extent, the quietude of the nervous system—and when the body has become habituated to them, so that the partial arrest of the function of the skin is compensated by increased activity of some other organ or organs—urate deposits are not of constant occurrence in the urine. Under such circumstances they appear on any aggravation of the cutaneous disease, either by diet, by cold, by bodily exertion, or by mental worry; but no sooner have these causes subsided and the increment of disease has passed away, than the urates cease to appear in the urine, and this fluid returns to the character it manifested under the stationary condition of the disease. Hence, in acute diseases of the skin, the appearance of urates in the urine has a somewhat different significance from that which they express when present in the urine of local inflammations. They do not express in the former, as they do in the latter, the cessation of exudation, its metamorphosis, and its removal from the body; but they rather show, in addition to the metamorphosis of the products of disease, disintegration of the bodily tissues caused by constant excitement of the nervous system arising out of the irritation on the surface of the body. In this view the urate deposits of the urine in acute

diseases of the skin are a measure of exudation-waste and tissue-disintegration; and, in the light of the latter, of the nervous irritation which has received its mental expression in pain, or in those unoasy sensations of heat, smarting, tingling, burning, stinging, and itching, which are the ordinary consequences of such affections of the skin.

As the presence of the urates in tho urine of acute diseases has a particular significance which has already been indicated, so their absence or partial absence from it in other instances, is a matter of considerable importance in tho prognostics of disease. If, for instance, the urine of variola, rubeola, or scarlatina, should not, after the acme of these diseases has been attained and when the eruption begins to decline, deposit a sediment of urates, a sequela is most certainly at hand. If, in acute gout or rheumatism, the improvement of a joint is suddenly followed by the disappearance of urate deposit from the urine, another joint is about to be affected. If, in typhoid fever, the urine remains clear and without a deposit of the urates at the time when the characteristic petechiæ or spots usually fade and disappear, it may be confidently predicted, that the fever is about to be prolonged, and that considerable danger will arise to the patient. In liko manner if, in the outset of albuminuria supervening on scarlatina, the urine is free from urate deposits, it shows a general affection of both kidneys; because, if one only of these organs were unaffected, or if the two were only partially affected, the unaffected portions would eliminate the products of the previous scarlatina in the form of the urates, which would appear as a sediment in the urine. On the other hand, when, in scarlatinic albuminuria, the urates appear as a deposit in the urine from which they have hitherto been absent, they are a sign of tho improvement which the kidneys are undergoing, and of the tendency of the disease to recover; because they show that the excretory action of the kidneys, which had hitherto been suppressed by the presence of disease, is in part restored, and that the disease itself of the kidneys has, at least to some extent, abated. In diabetes mellitus the occurrence of urate deposits in the urine may have a similar significance. In the outset of this disease, and for some time after its occurrence, it is not uncommon for urate deposits, uric acid in crystals, and phosphate mixed with oxalate of lime—the two former existing separately or together, and alternating with tho lime sediments—to occur in the urine; but when this disease has become chronic, such deposits are, as a rule, absent

from the urine. Now if, under this last mentioned condition, the urates should, either from the effect of treatment or without any assignable cause, be deposited in the urine, they show that the natural action of the kidneys has at least been increased, and they thus become a favourable increment in the future prognosis of the disease. With the presence of these deposits it will invariably be found, that the quantity of sugar has diminished, and that the natural urinary solids have increased in quantity. It will not unfrequently happen, that this increase of the natural solids of the urine is also attended by an increased secretion of urine, which may even reach twice the quantity which the patient had for months or years been voiding. But this increase does not continue. In a short time it falls to the previous quantity; then below it; and afterwards to the quantity of the healthy standard. In this declension there are a reduction of the quantity of sugar and an increase of the natural solids in such a ratio, that a density of 1·020 is reached with only a trace of sugar existing in the urine, where before the specific gravity was 1·033, whilst the natural solids of the urine amounted to the fraction of a grain only in the ounce of fluid, thus showing the urine to be little else than a mere solution of sugar in water. In such a case, of eleven years' standing, I was consulted but a short time ago. The treatment pursued had the effect of first increasing the quantity of urine very considerably, then of reducing the relative quantity of sugar and of increasing the relative quantity of the natural solids of the urine; and lastly, of reducing the quantity of urine almost to its natural standard, of diminishing to a great extent the quantity of sugar, and of increasing, in almost proportionate ratio, the natural solid constituents of the urine. These facts, properly interpreted, show—that there is a conservative power in the system, which, when properly assisted, tends to the complete removal of disease and to the perfect re-establishment of the healthy functions of the body—that the natural excretory action of the kidneys may be almost entirely suspended for years without the integrity of the structure of the kidneys being at all impaired—and that, on the removal of the disease, this action may be resumed and discharged with all the original efficiency of health. They further lead us to the conclusion, which has already received the confirmation of almost a generation of physicians, that diabetes mellitus, although it manifests its outward expression through the kidneys, is in no way a disease of the kidneys themselves—

and that, however long a case of diabetes may have existed, whatever may be the quantity of sugar which is present in the urine, and however fractional may be the quantity to which the natural solids of the urine have been reduced by the disease, hope of recovery under judicious treatment may be entertained.

In further considering the question of urato deposits in relation to disease, it may be important to know what practical inference, if any, can be drawn from the quantity and colour of the urates which are produced in the urine by disease. Now, as every inflammatory exudation must, in its removal from an organ which has no direct communication with any outlet of the body, be absorbed into the blood, and must undergo those transformations which enable it to escape through the excretory organs of the body, and as the kidneys are the great channels by which this office is performed, it is manifest that the urine will, in some way, indicate to a very great extent the measure of these transformations. This it does by the quantity of urates it lets fall after its emission from the bladder. If, then, in a case of local inflammation, the urine lets fall, on the abatement of the more urgent symptoms, a sediment of the urates, this occurrence may be accepted as a sure sign that the morbid action has ceased, at least for the moment, and that the disease tends in the direction of recovery. If the sediment is great, the probability is also great, that the improvement will advance; if small, that its continuance is uncertain, and that the influence of an adverse cause would assuredly excite a renewal of the disease. The quantity of sediment, however, must be judged according to the extent or severity of the inflammation and the particular structure or organ affected. In inflammation of all the larger organs, as the lungs, the liver, and the brain, as well as in inflammation of the pleura or peritoneum, we should expect that the cessation of active disease would be followed by a considerable urate deposit in the urine. The extent, however, of inflammation of these organs does not so much determine the quantity as the continuance of the urates. Thus, in single pneumonia, the metamorphosis of the exudation may at first produce quite as great a deposit of the urates as in double pneumonia, in which the extent of structures invaded by disease is twice that of the former; but the continuance of such deposit will be longer in double pneumonia than where one lung only is affected. Again, the deposit of urates may for a time be quite as great in the breaking up of an exudation in inflammation of one tissue of an organ as in that of inflam-

mation of all the tissues of which the organ is composed; but the duration of the deposit will be shorter in the former than in the latter. Hence, the urate deposit occurring on the removal of the exudation of a bronchitis will be of shorter continuance than that which accompanies the removal of the exudation of a pleuro-broncho-pneumonia; and so also with respect to other organs. In these, as in all instances of simple acute inflammation, the quantity of urate deposit in the urine becomes a measure of the progress of improvement: but in chronic inflammations, in pulmonary consumption, and in organic diseases which have already begun to undermine the general health, it has a somewhat different significance. In chronic inflammation there is an almost continued exudation taking place, with, however, occasional remissions or partial abatements of disease. During these remissions absorption to a certain extent of the exudation and its transformation occur, the products of which appear as urates in the urine. Thus far the urate deposits express an improvement for that particular time; but a fresh accession of inflammation occurs, the urates as a deposit disappear from the urine, and the improvement which their presence indicated, is again lost in the recurrent aggravation of disease.

In pulmonary consumption there are similar remissions and similar aggravations of the disease, with similar results and similar inferences. Tubercle is deposited from the blood; its advent is marked for the time by a certain excitement of the system and by local signs; the deposit ceases; urates appear in the urine, and the patient is better. Here, the deposit of urates is the measure of a temporary improvement in the removal of a certain portion of the exudation from the lungs; but, by-and-bye, another crop of tubercles is deposited in the pulmonary tissue; another excitement of the system occurs; again tubercle ceases to be deposited; again do urates appear in the urine; and again is the patient improved in his condition. Here the urates still indicate that the conservative power of the system is attempting the limitation and removal of the disease. At length the deposit of tubercle has become too great for the vitality of the pulmonary tissue to be maintained; the latter gives way; caverns are produced; low, continued inflammation surrounds them; softening of tubercle and disintegration of pulmonary tissue continue to progress; the products are partly expectorated, partly absorbed into the blood; urates occur in considerable quantity in the urine, and continue with scarcely a remission to the end. Here the presence of the urates is signi-

ficant of exudation-change and tissue-waste—of the progress of the disease to a fatal termination.

In that form of pulmonary consumption commonly known as "galloping consumption," the disease sets in with certain well marked local signs and general febrile disturbance; these never entirely remit; deposit rapidly takes place in the lungs; it and the tissue of the lungs as rapidly break down; urates appear from the first in the urine, and continue to the issue of the case in death. Here the deposit of urates is, from first to last, an expression of the progress of the disease; whilst their quantity is a measure of the rapidity with which it advances.

In organic diseases which have begun to produce their effects upon the general system, the urates are deposited in variable quantities in the urine. They may take their origin from the diseased organ itself, from the tissues of the body, and from the nitrogenised food. Change is going on in the tissues of the diseased organ itself; metamorphosis of muscular fibre is favoured by imperfect nutrition, and by the deterioration by disease of the vital force by which its atoms are held together; and the nitrogenised food is, by the weakening of the function of digestion, neither properly digested nor properly assimilated to the structures of the body. These conditions result in the formation of urates as the products of the transformations thus induced, and as such they seek their natural outlet through the kidneys, and appear as deposits in the urine. Their quantity and their constancy thus become an indication of the progress which marks their onward course to the grave.

From the colour of the urate deposits, as they occur in the urine, some inference may occasionally be derived as to their origin or the particular organ at fault. Their general colour varies from a dirty drab to a deep fawn or red brown. This is true of the urate deposits of fevers, inflammations, and functional disturbances of the digestive organs. In the outset of skin diseases involving a great portion of the surface of the body, as in eczema, psoriasis, lepra, scabies, rupia, and other affections, these deposits are sometimes overlaid by a pink, fleshy-looking layer, which consists of the urates stained with purpurine. Such is particularly the case when muscular rheumatism is associated with the diseases on which these urates depend. In acute articular rheumatism, in organic diseases of the liver, and in diseases involving the heart or respiratory organs, these deposits are not only stained with purpurine, but they

are often so intimately mixed with it, and it exists in such large proportion, as to give to the urine when shaken a deep lake red colour. When, then, urine of this colour is shown to the attendant physician, let him look for the cause to acute articular rheumatism, to diseases of the liver, to chronic affections of the lungs, and to diseases of the heart.

In the opposite extreme we find urate deposits in the urine of a white colour. They are more frequent in young children than in adults; and, in the latter, they occur more frequently in those whose nervous system is particularly sensitive and impressible to slight causes than in those whose strength and vigour bespeak a more robust constitution. They are essentially a non-inflammatory product, in which light they stand in marked contrast with the urate deposits already described. They have, however, an important significance in the element of diagnosis and in the use of remedies. They express the presence of mere nervous irritation rather than the existence of inflammatory disease. In this light they claim a position between the coloured urate deposits on the one hand and the phosphatic deposits of lime on the other—they neither express the inflammation of the former, nor yet the nervous depression of the latter. They nevertheless denote a condition of the system, which appropriate causes might push into inflammation on the one hand, or into phosphuria on the other. We are thus prepared to find them in the urine of children who are suffering from teething, from worms in the bowels, from remittent fever, and who are constitutionally irritable in their temper and disposition. In the adult several of these causes may operate in their production; but here they are not unfrequently produced, when produced at all, in the course of other diseases which involve considerable disturbance of the nervous system.

It has been shown that uric acid in combination with the alkalies, and especially with ammonia as one of the products of the metamorphosis of an exudation, constitutes the essentially inflammatory deposit of the urine. Uric acid, however, also occurs as a crystallised deposit in the urine. It is, therefore, interesting to know what significance its presence in this form bears to disease. On the first blush of the question it would seem natural to suppose, that, as uric acid in combination with the alkalies plays so important a part in all inflammations, it has itself, separately considered, a close relationship with inflammatory disease. Experience does not justify this inference. It is true that uric acid, in an

uncombined form, occasionally occurs in the urine of inflammatory disease towards its close; but this is so seldom the case that its presence in the urine, under such circumstances, may be regarded rather as an accidental occurrence than as a necessary condition of the disease. Hence, it may be safely affirmed, that the presence of uric acid in a crystalline form in the urine is significant of other than inflammatory disease. Now, the diseases with which it is more particularly associated are—muscular rheumatism and disorders of the digestive organs. In its association with rheumatism it takes its origin in suppressed secretion of the skin. A part of the body is exposed to a draught of air or cold wind; it shortly afterwards feels stiff; the patient experiences a sensation of chill, and in a few hours voids urine which, on cooling, deposits crystals of uric acid. Here, the suppressed secretion of the skin and the consequent throwing back upon the blood, if not of an acid, at least of a nitrogenised material convertible into uric acid, rouse the conservative action of the kidneys, by which uric acid is separated from the blood, and passed off in the urine, from which it is deposited in its well-known crystalline forms. Rheumatism thus affecting the system is not of an inflammatory character; there are no swellings of the joints—no exudation—no redness of the skin—no tenderness on manipulating the joints—no thirst—none of the symptoms of inflammatory fever. It is but the expression of functional disturbance of the skin, which is sufficient to destroy for a time the balance and harmony of action of the different organs, and to excite discomfort to an indefinite degree; but which falls short of producing local inflammation. Where local inflammation exists, as in acute articular rheumatism, there is a necessarily consequent exudation, which, in the metamorphosis it undergoes in its removal from the diseased joint or structure, is partly converted into ammonia, with which the uric acid combines, and is thereby prevented from assuming a crystalline form in the urine. In the muscular rheumatism just mentioned there is no such local exudation—no breaking up of an inflammatory product—no consequent formation of ammonia—no such base to seize the uric acid; the latter is therefore deposited alone. But uric acid in crystals is not always deposited in the urine of muscular rheumatism excited by suppressed action of the skin. It as often appears in that secretion in combination with ammonia as a separate deposit; and when it does so, it simply shows that the ammonia was derived from the transformation of the nitrogenised portion of the suppressed pers-

piration, and not from inflammatory exudation. The necessary conclusions to which these facts lead us are—that uric acid in crystals is commonly deposited in the urine of muscular rheumatism; whilst its presence as such in the urine of acute articular rheumatism is seldom witnessed—and that, while urate of ammonia not unfrequently occurs as a deposit in the urine of muscular rheumatism, it is the essential salt of the deposits which occur in the urine of the acute articular form of this disease.

In diseases of the heart uric acid deposits in the urine are not of unfrequent occurrence; but knowing, as we do, that most of the affections of the heart are dependent on rheumatism as their cause, it seems more consonant with true pathology, as to the genesis of uric acid in disease, to regard the deposits of this acid in the urine as connected more with the rheumatic diathesis of such patients than with the mere heart disease, simply considered as such. In this, as in every other organ, uric acid alone is not the deposit which occurs in the acute inflammatory affections of the heart. It is in the chronic affections of this organ that it assumes a free, crystalline form in the urine; whilst urate of ammonia, as a deposit in this secretion, is the common expression of acute disease.

In all diseases, functional or organic, of the stomach, in which an excess of acid is secreted by that organ, deposits of uric acid are apt to occur in the urine. In irritable dyspepsia, in pyrosis, and in the early stages of organic disease of the stomach, this deposit is of frequent occurrence. The stomach, in such cases, secretes an excess of acid; this passes into the blood; it finds its way to the kidneys, is eliminated, and passed off in the urine, in which it displaces the uric acid from its combinations, and causes it to be deposited in a crystalline form. This is certainly one mode by which the uric acid deposit is produced; but it is also probable, that a portion of the free acid generated in the stomach, is digested and broken up into its ultimate elements, and that these elements, in their transit through the system, combine with the elements of the protein compounds of the food in such proportions as to form uric acid, which appears in absolute excess in the urine. Without some such explanation as this it would seem to be impossible to account for the great quantity of uric acid which sometimes appears as a deposit in the urine when little or no animal food has been taken, and when the tissues of the body have not by exercise, or in any other way, been subjected to any undue waste. So great indeed, is the deposit of uric acid in the urine, in many

of such cases, that it has been regarded as evidence of the existence of a peculiar diathesis which has taken the position of an important disease. Whether or not it is entitled to assume this rank in the nosology of diseases, or whether it ought to be regarded as the effect only of a depraved digestion, is a matter of no consequence whatever so long as the treatment is properly directed to the organs which are known to be at fault. Uric acid is not always excreted alone and in such quantity as to appear as the only deposit in the urine. It, on the contrary, is often associated with urate of ammonia and with phosphate and oxalate of lime. These two last mentioned salts give to the urine on cooling a milky appearance, and to the sediment which subsides, a flocculent consistence and a white or dirty-white colour. When uric acid is thus associated with the lime salts, it is an evidence of the existence of nervous irritation and of a certain amount of prostration of the vital powers. It may thus occur in the course of long diseases, in which pain, and especially pain in the neighbourhood of the kidneys, is a frequent element—in injuries to the loins—and at the close of acute diseases. Hence, this association of uric acid, urate of ammonia, and the salts of lime, is frequently to be found in the urine of diabetes mellitus after an aggravation of the lumbar pain which is so commonly felt in this disease—in the urine voided after blows or other injuries received over the loins or bladder—and in the urine of scarlatinic nephritis towards its close. The microscopic examination of the sediment in such cases usually shows the uric acid in diamond or lozenge-shaped crystals and square tables, sometimes of a light fawn colour, at other times colourless—the phosphate of lime in irregular, amorphous particles—and the oxalate of lime in the well-known, beautiful forms of the octahedra of this salt.

Such, then, are the conclusions to which a long series of clinical investigations of the urine has led me. My subject is by no means exhausted; but the present opportunity does not permit me to continue its further consideration. This, however, I hope on a future occasion to resume, and ultimately to place before you in connected whole that of which I now offer you, and through you the whole medical profession, an important part. I am aware that in the attempt to systematize facts which have hitherto in the descriptions of disease presented themselves in a confused and chaotic form—in the drawing of inferences from facts diligently observed and carefully considered—and in enunciating views which, whatever

novelty they may have, are nevertheless to me subjects proved and deductions legitimately borne, I cannot hope to have done my work without error, without imperfections, without faults of some kind. But to whatever extent this error, these imperfections, and these faults may exist, I have confidence, implicit confidence, in the general results at which I have arrived. I therefore commit my present labours to the opinion and judgment of the medical world; I invite its criticism; I court not its favour; because I know, and I rejoice in the fact, that as error must eventually fail in its grasp on the human mind, so truth in the light of knowledge will live, and bear its fruition after many days.

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